Genetic Programming: An Application

Andrew Kusiak,
Intelligent Systems Laboratory
2139 Seamans Center
The University of Iowa
Iowa City, Iowa 52242 - 1527

andrew-kusiak@uiowa.edu
http://www.icaen.uiowa.edu/~ankusiak
Tel: 319 - 335 5934        Fax: 319 - 335 5669

Based on the material provided by Professor W. Pedrycz.

Evolvable Hardware

• Evolvable Hardware: Definition
• The principle
• Main features

Bio-inspired Systems

The ultimate goal of bio-inspired engineering is to develop adaptive systems that are capable of undergoing modifications (adaptation) according to changing circumstances, thus ensuring their continuing functionality.

FPGA - an Enabling Technology of Evolvable Systems

• FPGA: circuits that can be modified or configured by an end-user
• Configuration (realized by a configuration string)
FPGA = Field-Programmable Gate Array

FPGA: Definition

Field-Programmable Gate Arrays (FPGAs) are a recent kind of programmable logic devices. They allow the implementation of integrated digital electronic circuits without requiring the complex optical, chemical and mechanical processes used in a conventional chip fabrication. FPGAs can be embedded in traditional system design flows to perform prototyping and emulation tasks. In addition, they also enable novel applications such as configurable computers with hardware dynamically adaptable to a specific problem.

http://www.icsi.berkeley.edu/~akoch/research.html
http://www.mrc.uidaho.edu/fpga/fpga.html

FPGA - Configuration

• Configuration (realized by a configuration string)
  – static: configuration of the circuit to perform a given task, does not change during the execution of the task at hand
  – dynamic: configuration that changes during execution of the task at hand
Evolvable Hardware

FPGA + Evolutionary Computing

FPGA = Field-Programmable Gate Array

Evolvable Hardware:
The Principle

Configuration string
01100011100011

Configuration string
111000111000110001

Evolved design

Phenotype
“space”

Evolvable Hardware:
Levels of Adaptation

- Adaptation to changing operational environment
- Adaptation to changing requirements
- Adaptation to partial hardware failure
- Fabrication defect adaptation

FPGAs in EHW development

Microphotograph of XC6216 FPGA enlarged 20 times

Xilinx, Inc.’s XC6200 series FPGAs are especially well suited for EHW development due to their unique architecture: it is impossible to electrically damage these FPGAs by applying random configuration bitstrings.

FPGA = Field-Programmable Gate Array

Evolvable Hardware:
Selected Applications

- EHW chip for cellular phones
  Combating inherent implementation problem of analog circuits associated with differences from precise design specifications

- Data compression chip for printing
  Data compression for electrophotographic printing (EP)